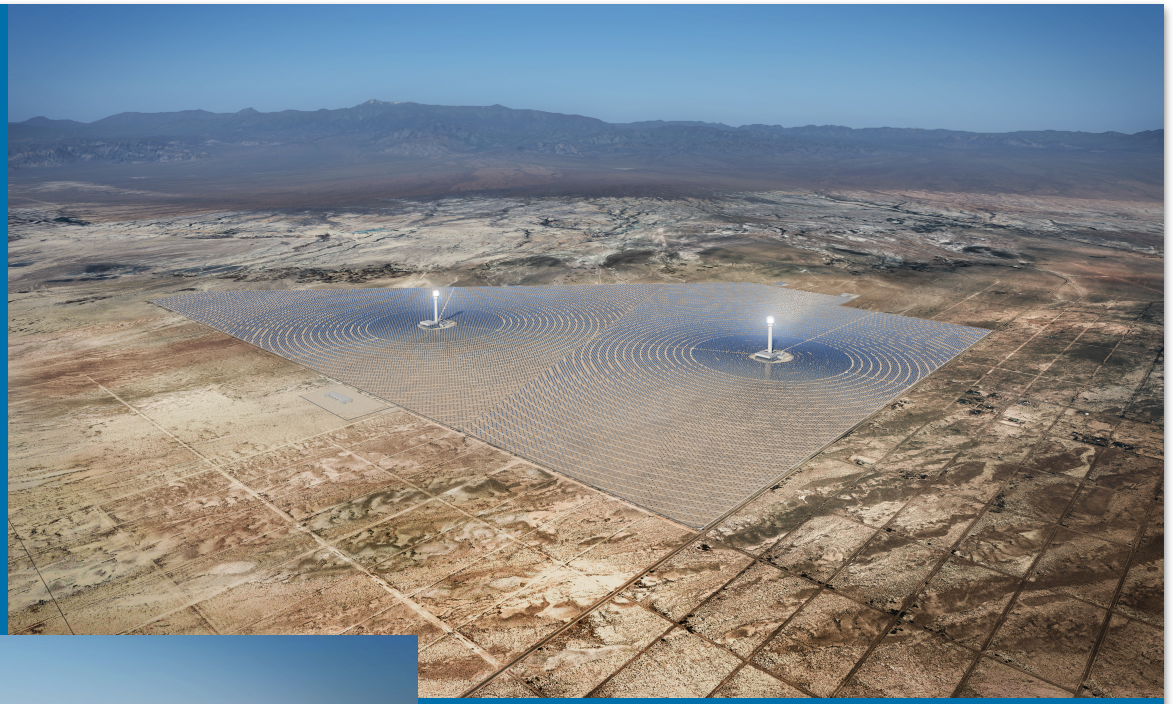
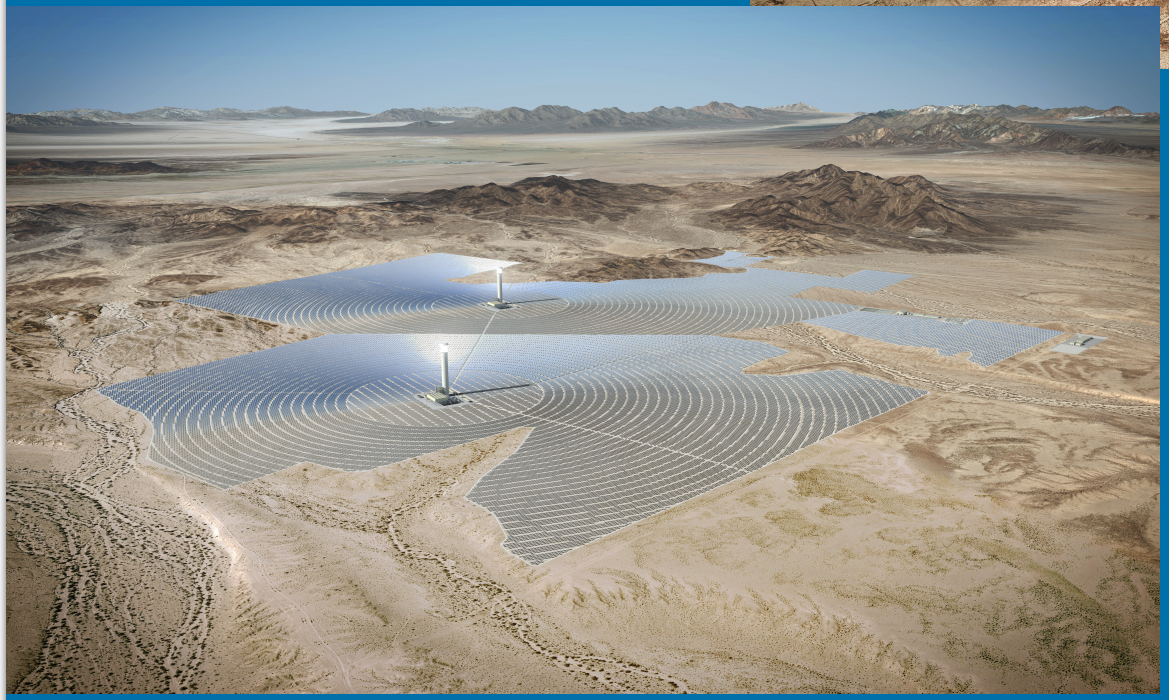
CEC JOINT WORKSHOP

FLUX IMPACTS ON AVIAN SPECIES

AUGUST 28, 2012



HIDDEN HILLS SEGS



RIO MESA SEGF

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Workshop Purpose

Explain solar flux and clarify its potential effects on avian species.

Agenda

- Introduction and Body of Work – Chris Ellison
- CSP Refresher and Solar Flux – Todd Stewart/Danny Franck
- Avian Solar Flux Study at SEDC – Gary Santolo
- Conclusions – Chris Ellison
- CEC/CBD/CMcD Written Questions - Various

Flux Interactions at SEDC, Israel

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Body of Work

Chris Ellison

Actual Experience at Solar Power Towers

Solar One, Daggett, San Bernardino County, California

- Avian Mortality at a Solar Power Plant, McCrary et al. January 1986

- 40 weeks of surveying, 1x/week
  - 70 fatalities (26 species), 20-30% scavenger rate
  - 81% of bird deaths by collision, 13% mortality at standby points (Solar 1 standby point flux was 3x max flux at RMS or HHS)
    - 2 Swifts, 2 swallows, 2 warbler, 1 hummingbird, 1 sparrow (no raptors or eagles, even though they exist in SB County).
- "Considering all known avian fatalities (70 birds) at Solar One during this study, the impact of the facility on birds after construction appears minimal."

Plant Statistics

Mirrors were approx 510 ft^2 (47m^2) and 25 ft high

Solar field includes 1818 heliostats

Tower is 86m in height.

Actual Experience at Solar Power Towers

SEDC, Negev Desert, Southern Israel

- Located adjacent to the Syrian-African rift valley flyway.
- No birds with singeing in 4 years of operation as reported by Operations Staff.
- SEDC - USFWS Survey Protocols (Nicolai et al. 2011) implemented April 2012. (4x/week @ 20m transects)
- 41 Days of Monitoring Data – Three avian fatalities discovered.
  - One nestling apparently fell from a nest in the lattice tower.
  - Two birds within the solar field, no signs of singeing.
  - No evidence of collision injuries on any bird

Plant Statistics

Mirrors were approx 75-150ft^2 (7-14m^2) and 10-11 feet high.

Solar field includes 1760 heliostats

Tower is 65m in height.

Actual Experience at Solar Power Towers

GEMASolar, Andalusia Spain

- GEMASolar – Andalusia – Impact of GEMASolar Plant on Bird Population, Report No. 4, Pleguezuelos et al., September 2010 Construction Impacts
- GEMASolar – Andalusia – Area known for high avian species concentration, Pleguezuelos et al., August 2012 (Conclusions)
  - 14-month study under the direction of Dr. Pleguezuelos, Department of Zoology, University of Grenada
    - No avian fatalities reported during the 2 days of "painstaking " search in vicinity of the collector tower.
    - Common raptors appear unaffected.

Plant Statistics

Mirrors were approx 1075 ft^2 (100m^2) and

~50 feet in height

Solar field includes 2650 heliostats

Tower is 140m in height.

Information on Flux in Data Responses

- Hidden Hills Solar Response to CEC Data Request 29, November 2011
- Hidden Hills Solar Response to CEC Data Request 57, November 2011
- Rio Mesa Solar Response to CEC Data Requests 143 through 144, February 2012 (ocular issues)
- Rio Mesa Solar Response to CEC Data Requests 145 through 147, February 2012
- Rio Mesa Risk Characterization Report to CEC, February 2012
- Hidden Hills Solar Response to CEC Data Requests 161 through 171, April 2012
- Rio Mesa Solar Response to CEC Data Requests 55 and 57, May 2012
- Rio Mesa Solar Response to CEC Data Request 159, July 2012

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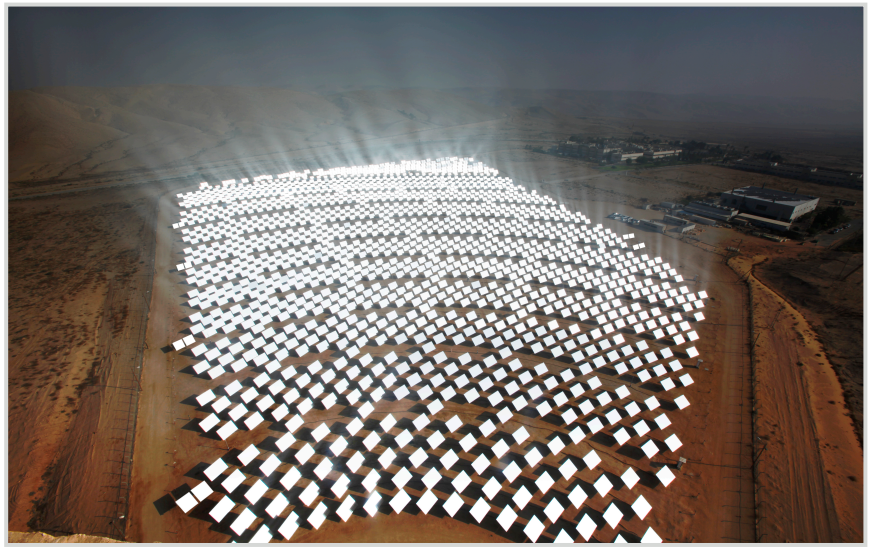
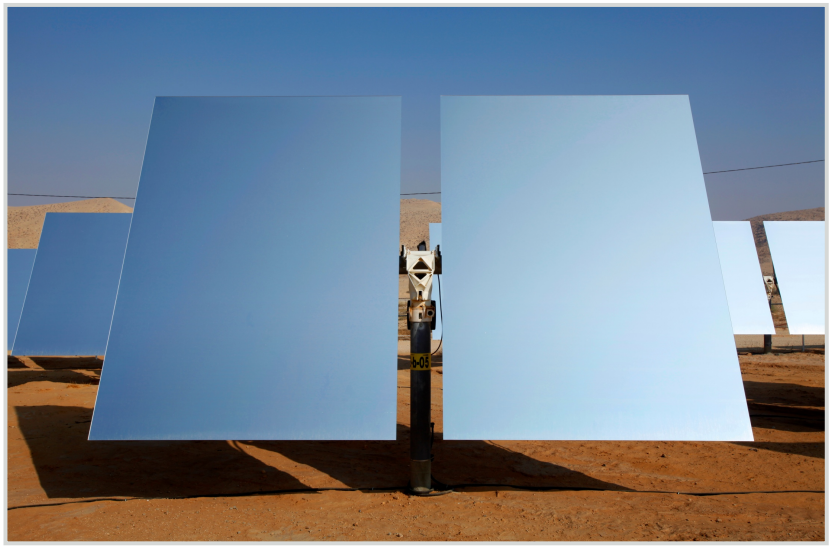
CSP Tower Technology Overview

Todd Stewart/Danny Franck

Technology Overview

Heliostats Overview





Two flat glass mirrors mounted on a single pylon equipped with a computer-controlled drive system

Solar Field Optimization Software and Control System (SFINCS)

- Software determines the optimal position of each heliostat accounting for the unique conditions of each project site
- The SFINCS control system manages distribution of solar flux across the solar receiver using real-time heliostat-aiming and closed-loop feedback.

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Solar Flux

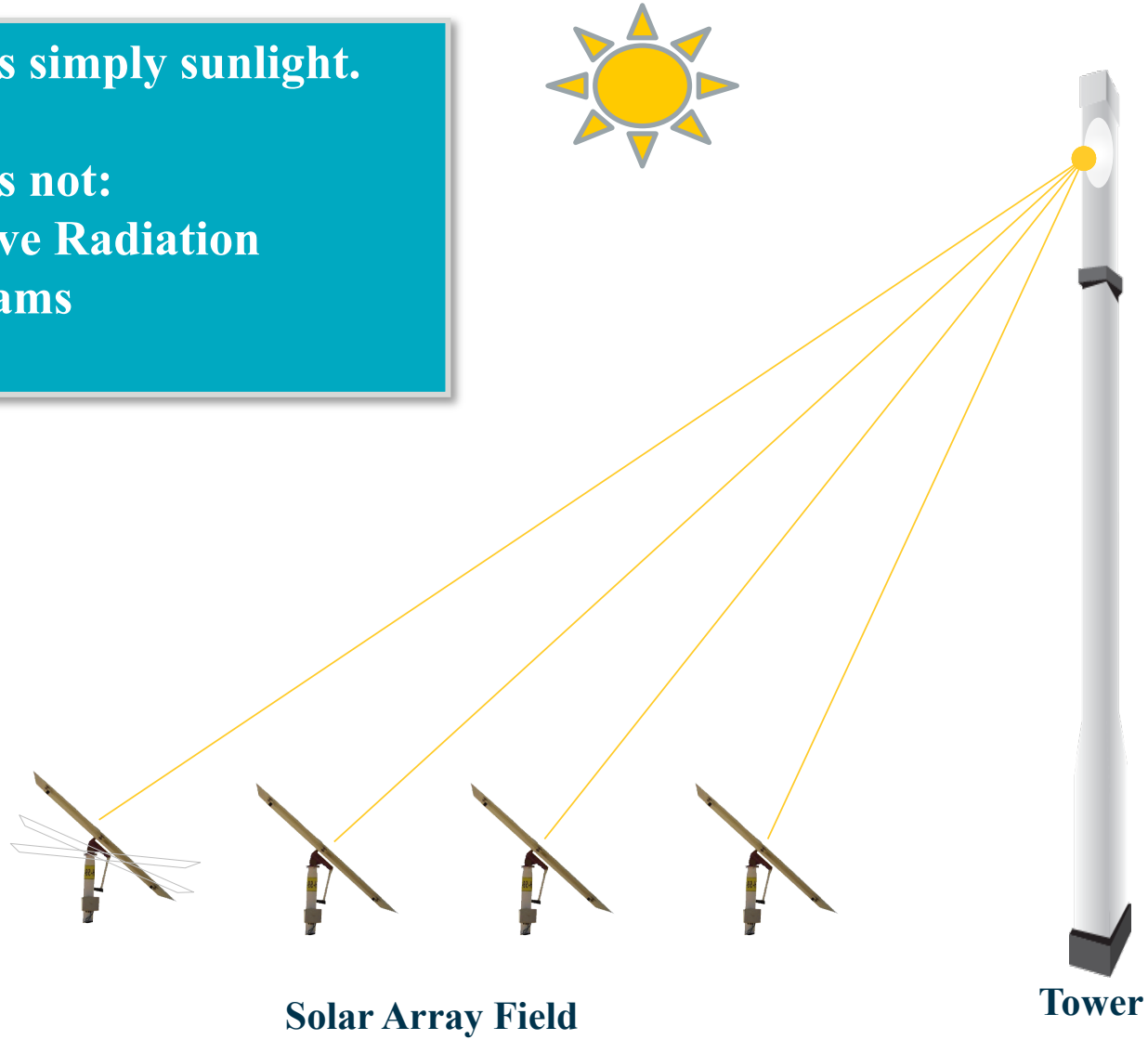
Todd Stewart/Danny Franck

What is Solar Flux?

Solar Flux is simply sunlight.

Solar Flux is not:

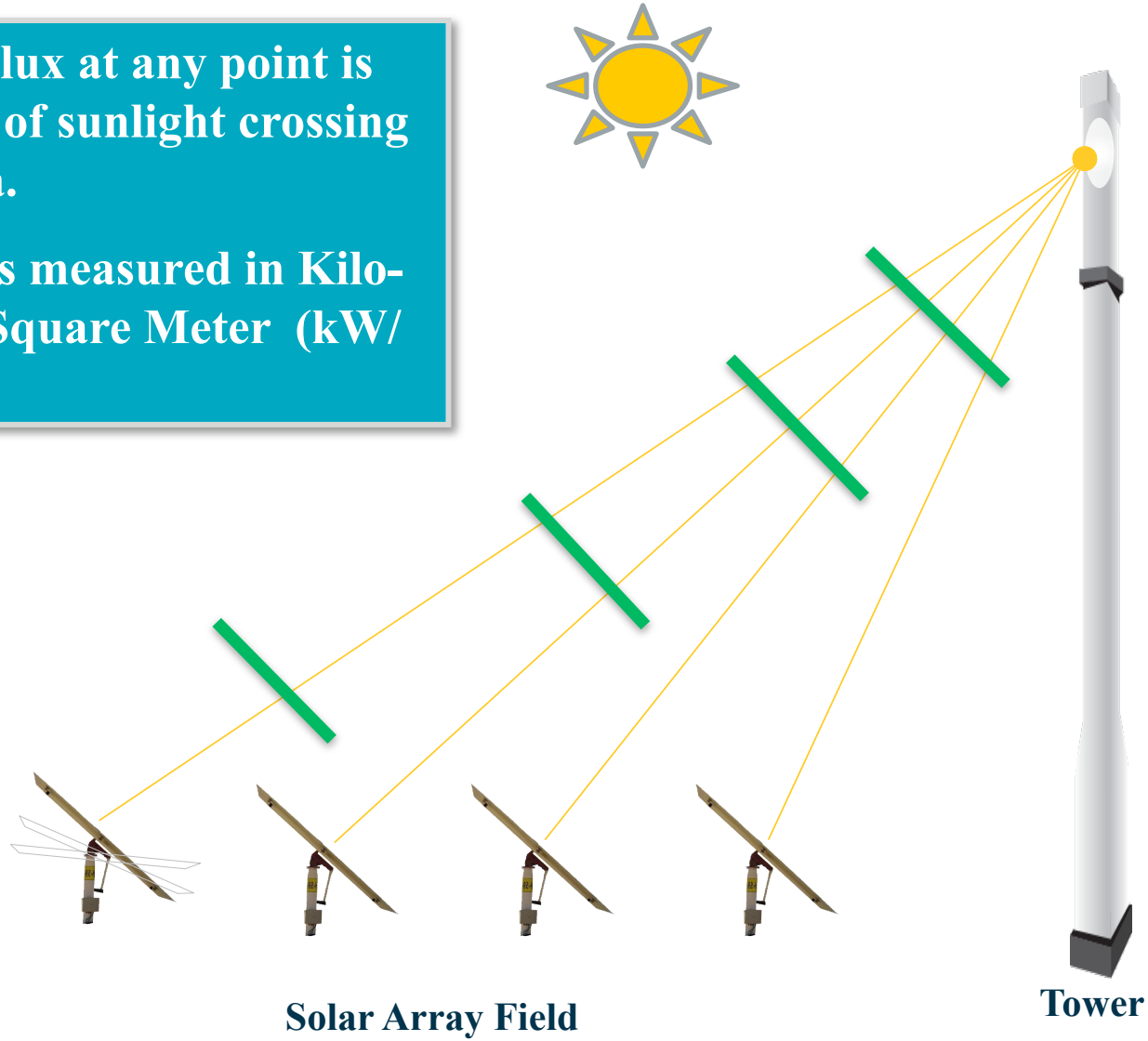
- **Microwave Radiation**
- **Laser beams**
- **Heat**



What is Solar Flux?

The Solar Flux at any point is the amount of sunlight crossing a given area.

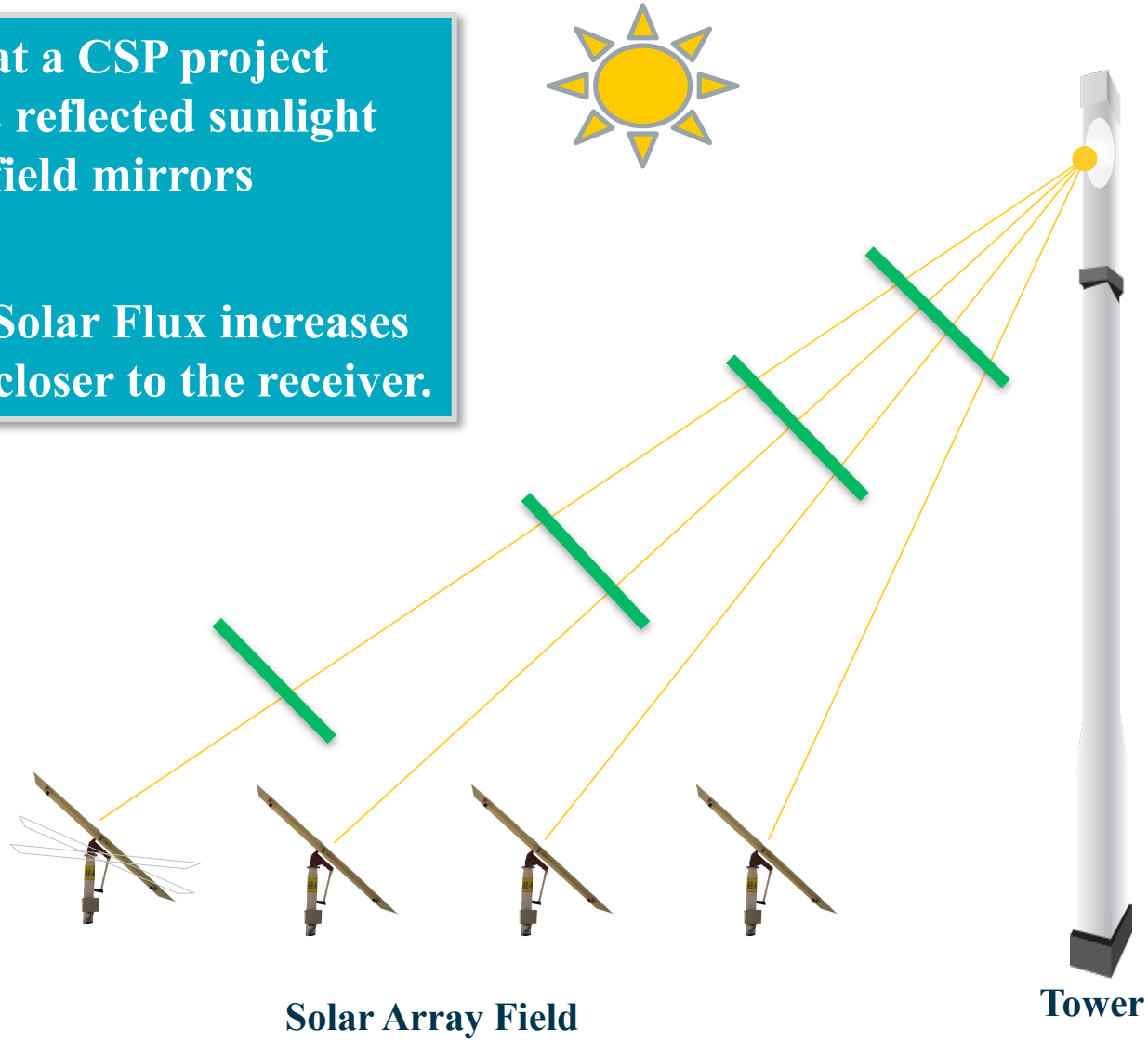
Solar Flux is measured in Kilo-Watts per Square Meter (kW/ M^2).



What is Solar Flux?

Solar Flux at a CSP project increases as reflected sunlight from solar field mirrors converge.

Therefore Solar Flux increases as one gets closer to the receiver.

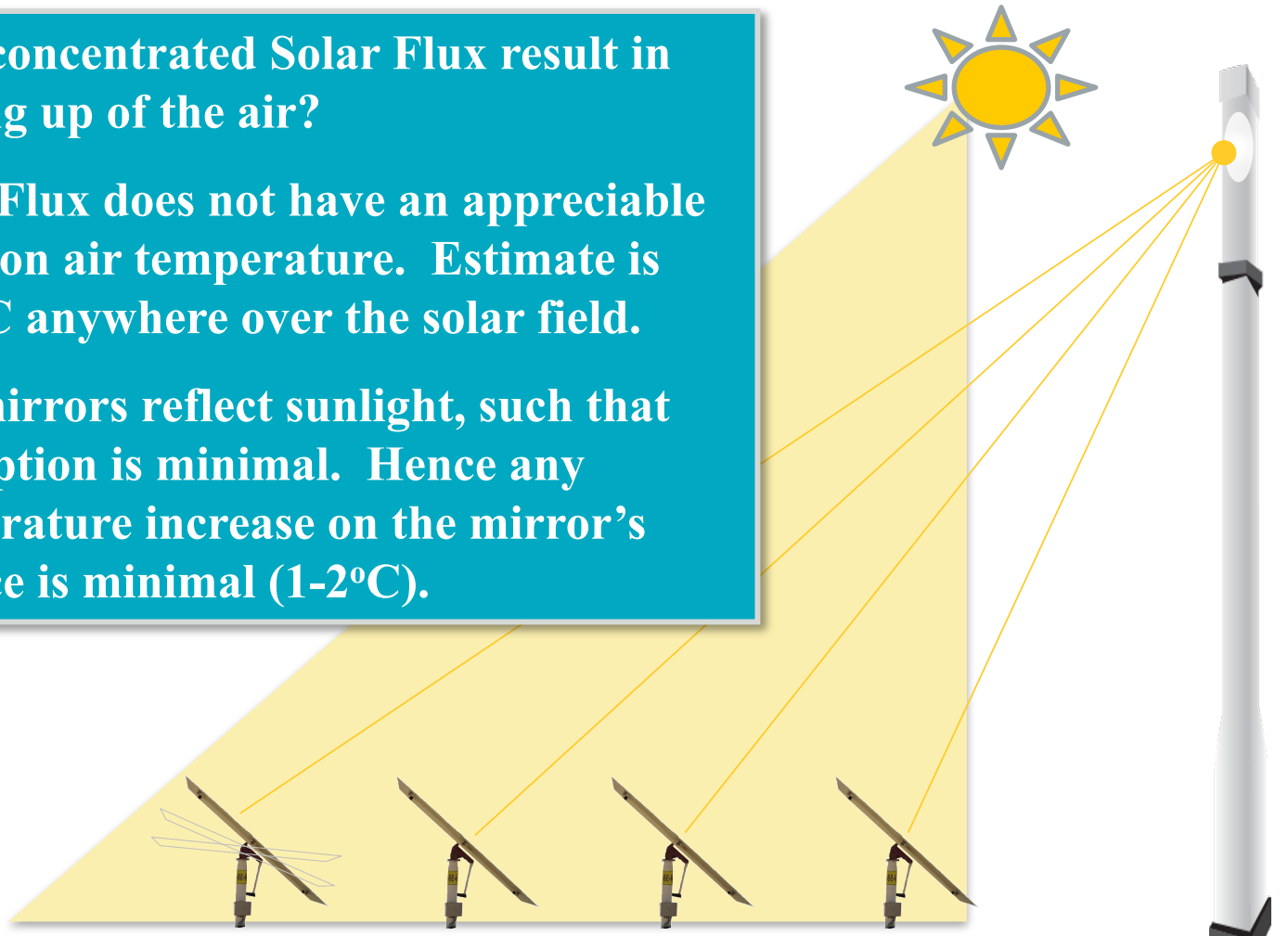


Solar Flux Characteristics

Does concentrated Solar Flux result in heating up of the air?

Solar Flux does not have an appreciable effect on air temperature. Estimate is <0.1°C anywhere over the solar field.

The mirrors reflect sunlight, such that absorption is minimal. Hence any temperature increase on the mirror's surface is minimal (1-2°C).



Solar Array Field

Tower

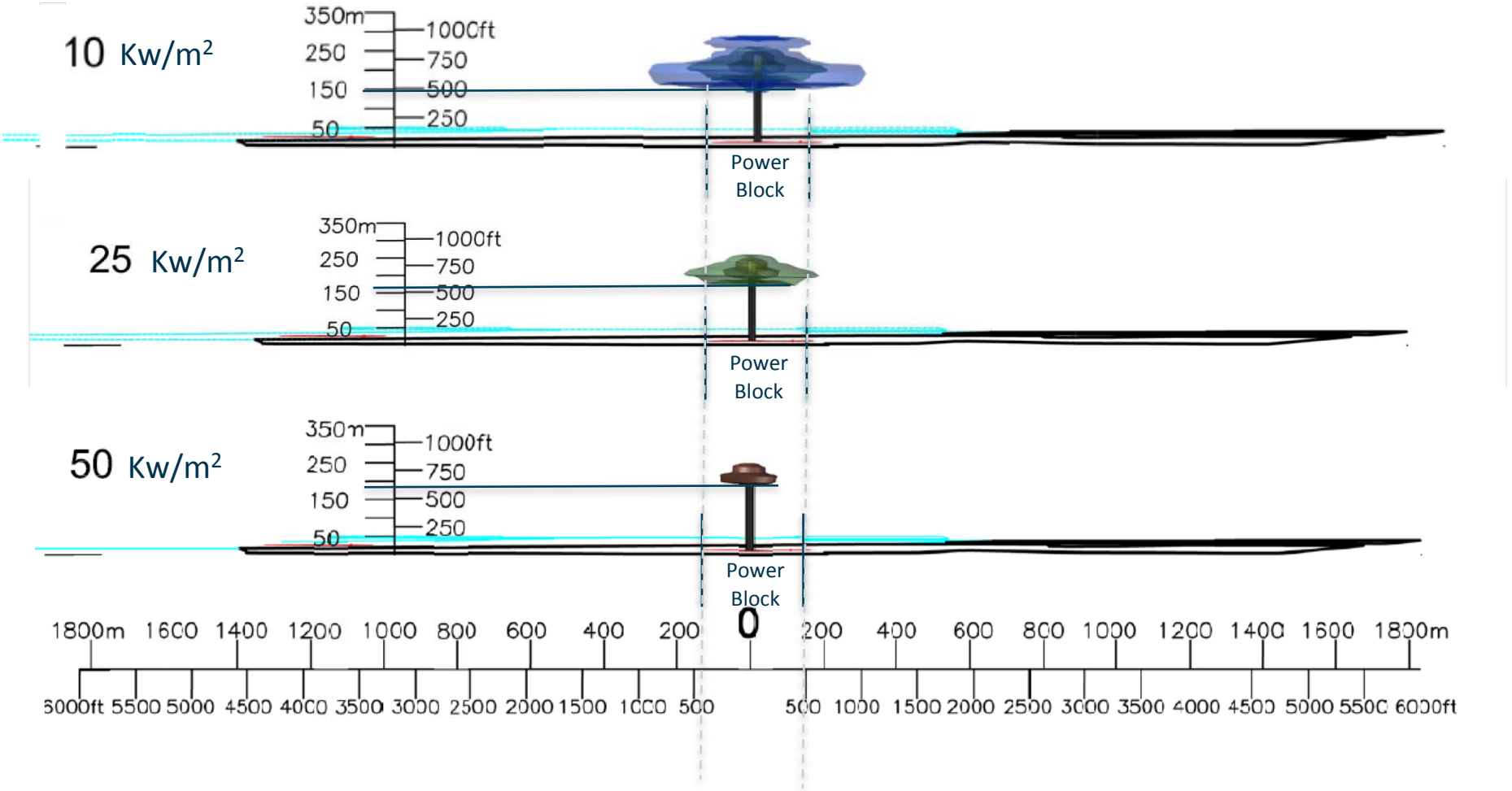
Solar Flux Modeling Methodology

Solar Flux is modeled as described below.

- Computer simulations simply sum the flux that is coincidental from each mirror.
- Total flux is then determined for a particular airspace location.
- The data is contoured to provide depictions of flux concentration around the tower.

Typical Flux Concentration Increase (fix

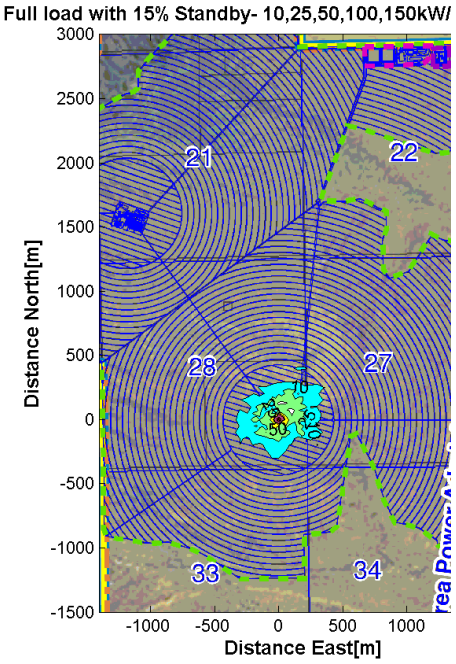
As described in the previous slides the solar flux concentration increases as it approaches the receiver



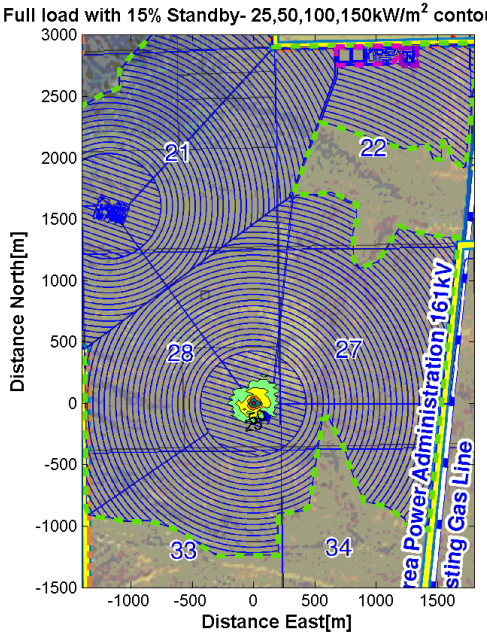
Modeled Flux Concentration

Modeled Plan View of various solar flux concentration at Rio Mesa

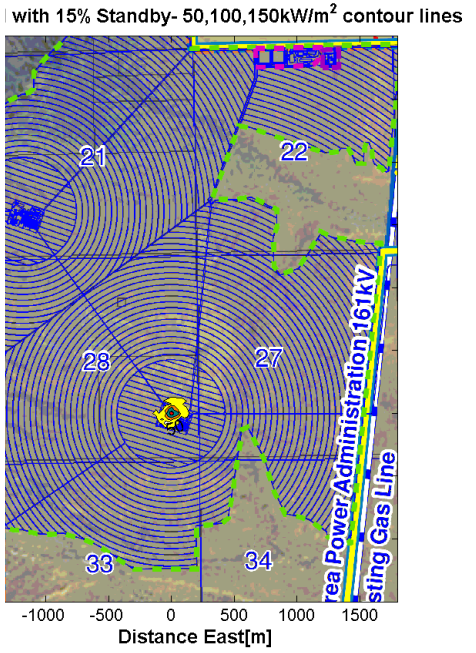
>10 kW/m^2



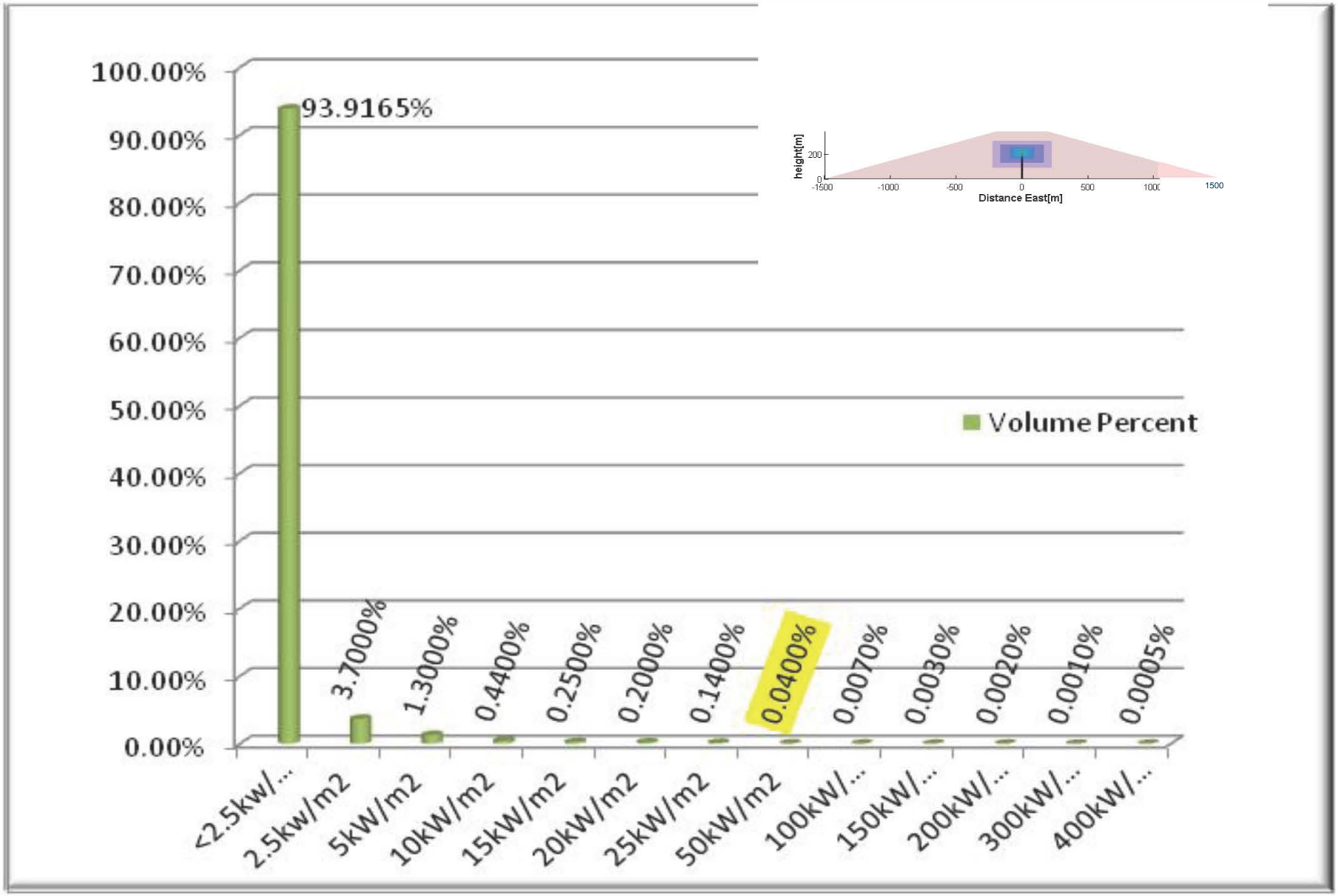
>25 kW/m^2



>50 kW/m^2



Solar Flux Modeling Results



Solar Flux Modeling Results (continued)

- Flux levels greater than 50kW/m2 occur only from 190 to 240 meters above ground surface and within 65 meters (+ 10 meters from center of tower) from the central tower surface.
- Only 0.04% of the air space over the facility (see previous slides) in close proximity with the upper portion of the tower experiences flux levels greater than 50kW/m^2.

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Avian Flux Study at SEDC

Gary Santolo

Gary Santolo – CV Highlights

- BS and MS in Avian Sciences, UC – Davis
- North American Director, Raptor Research Foundation
- Professional Registrations (current):
  - Joint California and Federal Scientific Collecting Permit No. 002407
    Master Banding and Salvage Permit No. 22717
    Federal Migratory Bird Permit No. PRT-829185
- 24 years as a wildlife biologist and toxicologist. Serves as a senior technical reviewer for wildlife-related sections of CEQA/ NEPA documents, Biological Assessments, and Section 7 consultations with USFWS.
- Developed and co-authored a report recommending guidelines for conducting ecological risk assessments in California for EPA.
- Over 20 technical publications spanning more than 20 years.

Avian/Solar Flux Interaction Study

- A study of the impacts to avian species from solar flux was conducted at the SEDC facility in the Negev Desert in Israel during July 2012.
- Study was in response to questions asked by the California Energy Commission.
- The study was intended to investigate the question:

  What is the concentration of solar flux below which no observable effects on birds would be expected?

Avian/Solar Flux Study - Methods

- Test avian carcasses were exposed to solar flux for time intervals of up to 30 seconds at a known flux level.
- 12 Small (quail), 12 medium (pigeon) and 12 large (chicken) birds were selected for testing to simulate flux effects over a range of species.
- Each bird was used in only 1 test.
- Flux concentrations ranged from 8.3 and 78.3 kW/m^2.
- A reference bird of each species was exposed to normal sunlight, ~1 kW/m^2, for 60 seconds to establish baseline internal and external temperatures.
- Test birds were at ambient temperature prior to testing.

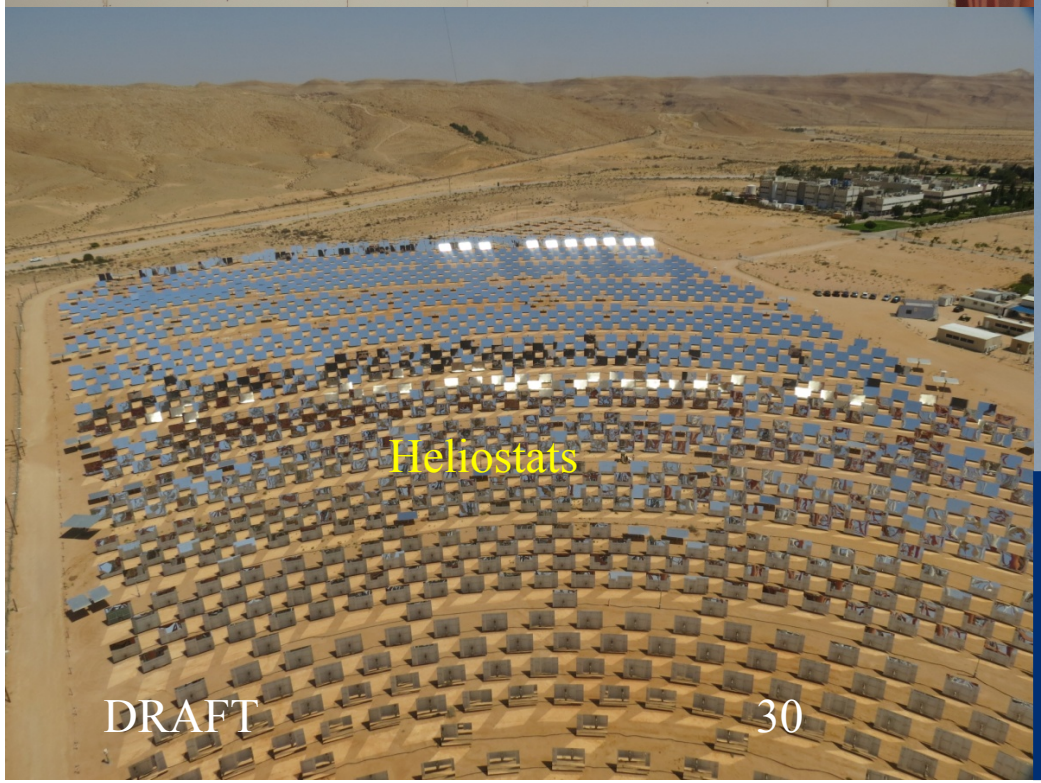
Avian/Solar Flux Study - Methods (cont)

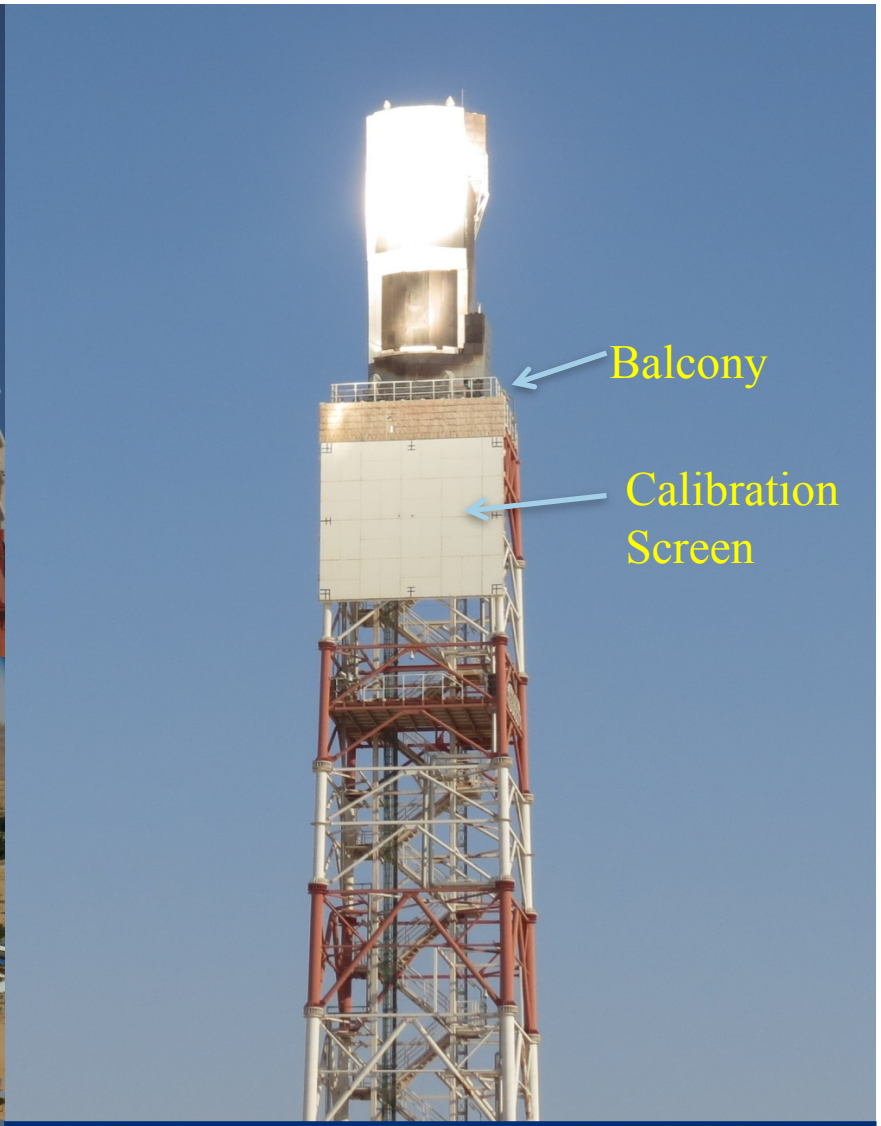
- Test birds were fitted with internal and under the skin (just under the feathers) thermocouples
- Bird external (feather) and internal temperatures were taken immediately before and after each test.
- Following exposure, the subjects were immediately examined for external (feather) effects.
  - Birds with feather effects were further examined for tissue effects through post-exposure dissection.
- Following the testing, a reference group of birds without feather effects were also examined for tissue effects.

Avian/Solar Flux Interaction Study

Assumptions:

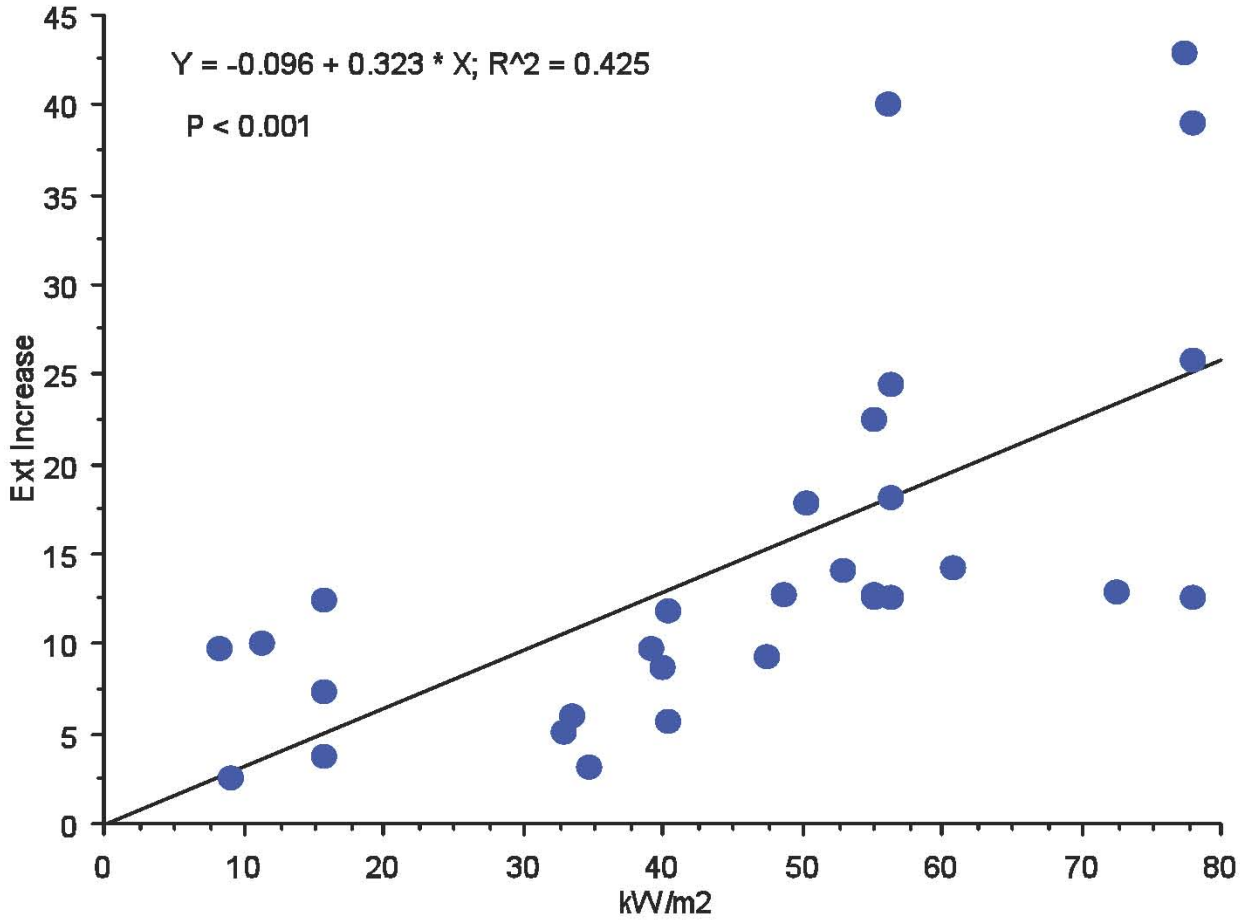
- The average flight speed of birds at RMS and Hidden Hills is approximately 14 meters per second.
  - Exposures of up to 30 seconds correspond to a distance covered in flight of up to 420 meters by a bird at the average flight speed.
- Static dead birds provide a conservative estimate of solar flux effects relative to live birds.
  - The movement of live birds modulates exposure to solar flux.
  - Live birds dissipate heat through convection, evaporation, and heat storage.



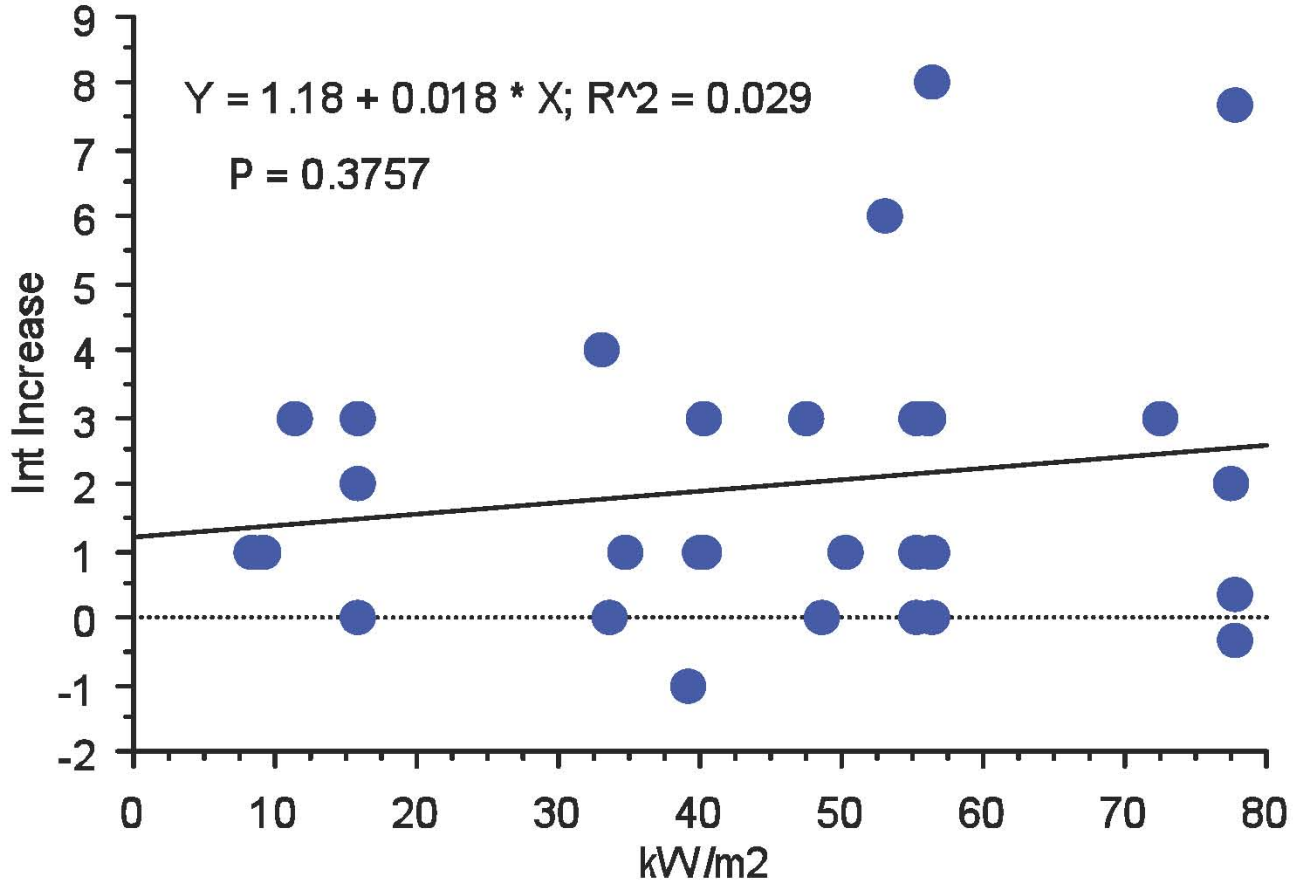


Birds, with thermocouples for measuring temperatures under the skin and internally, were lowered to the center of the calibration screen at the SEDC facility in the Negev Desert.

Temperature Data – External Data



Temperature Data – Internal Sensors



Observed Data – Individual Effects

Quail	Muscle						✓		✓	✓	✓	✓	✓
	Feather						✓		✓	✓	✓	✓	✓
	No Effect	✓	✓	✓	✓	✓							
	kW/m2	11.3	15.8	33	40.4	47.4	53	55.2	56.4	72.6	77.9	77.9	77.9

Pigeon	Muscle									✓	✓		
	Feather					✓	✓	✓	✓	✓	✓	✓	✓
	No Effect	✓	✓	✓	✓								
	kW/m2	8.3	15.8	34.8	40.4	50.4	55.2	56.1	56.4	77.4	77.9	77.9	77.9

Chicken	Muscle													
	Feather							✓	✓		✓	✓	✓	
	No Effect	✓	✓	✓	✓	✓	✓							
	kW/m2	9.1	15.8	33.5	39.1	40	48.7	55.2	56.4	60.9	77.9	77.9	77.9	78.3

Solar Flux Level

Observed Data – Combined Effects

Solar Flux Level

Results

- No observable effects on feathers or tissue were found in test birds where solar flux was below 50 kW/m^2 with exposure times of up to 30 seconds
- Effects were observed at solar flux levels above 50 kW/m^2 with exposure times of 20 to 30 seconds as follows:
  - Effects observed on feathers in 19 of 22 birds
  - Effects observed in muscle tissue in 8 of the 19 with feather effects;
  - None of the 7 chickens showed muscle tissue effects;
  - Two of the 8 pigeons showed muscle tissue effects;
  - Six of the 7 quail had muscle tissue effects.

Results - Continued

- Feather color appears to influence effect:
  - Four of four chickens with black plumage exposed to flux above 50kW/m^2 showed feather effects,
  - One of three chickens with white plumage exposed to flux above 50kW/m^2 showed feather effects.
- These results are conservative due to the following factors:
  - Live birds actively dissipate heat through behavior, convection, evaporation, and heat storage.

Conclusions

- There were no observable effects to avian carcasses of any tested size at solar flux concentrations below 50 kW/m^2
- Larger birds showed less impacts.
- Lighter-colored birds were less affected.
- Avian carcasses provide a conservative indicator of solar flux effects relative to live birds.
- Based on these results, no effects on live birds are expected at solar flux concentrations below 50 kW/m^2 for up to 30 continuous seconds.

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Conclusions

Chris Ellison

Overall Conclusions on Solar Flux

- Solar One technology is very different from today's power tower projects.
- Studies of existing modern Power Tower technologies have consistently shown no significant evidence of solar flux impacts to avian species.
- Impacts to avian species at solar flux concentrations below 50 kW/m^2 are very unlikely.